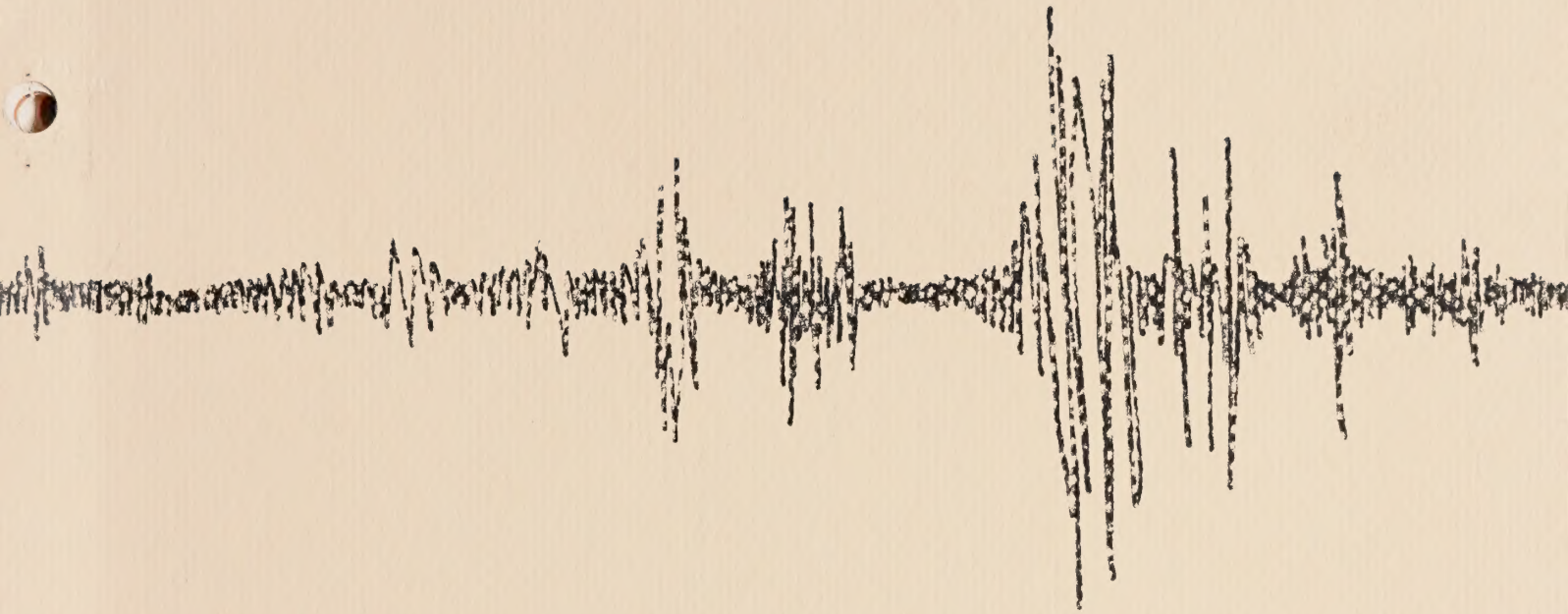


City of San Leandro

SEISMIC SAFETY ELEMENT

SEISMIC SAFETY ELEMENT

of the San Leandro General Plan

Community Development Office
City of San Leandro, California

June 9, 1977

Introduction

The Seismic Safety Element of San Leandro's General Plan is one of the ten elements of the plan. It is a required componenet of all City and County General Plans by state law. The Element is a basic policy document, intended to provide the framework within which specific actions by the city, other government agencies, and private entities will be taken. As a part of the General Plan, it must be consistent with the other parts, particularly the Land Use and Circulation, Housing and Open Space Elements. As the first Seismic Safety Element for San Leandro, it should be understood that it will be subject to change as the city's awareness and knowledge of seismic hazards increases.

Because seismic safety involves a great deal of rather technical information, a "Safety Seismic Element - Supplement" has been prepared to accompany this policy summary. The supplement includes the detailed description and explanation of seismic hazards in San Leandro and a discussion of acceptable risks.

What Can San Leandro Do About Earthquakes?

As almost all Californians are aware, earthquakes and related natural hazards cause a serious and continuing threat to people, property, and the overall economic stability. As a city traversed by a major fault, this is especially true for San Leandro. The city cannot prevent earthquakes, but it can work to limit future earthquake losses. That, in turn, depends on the level of risk that is acceptable in the community. In simplest terms, "unacceptable risks" are those dangers to the health and safety of its residents that warrant actions by the city. In general, the level of risk which is acceptable:

- decreases as buildings are used more;
- increases when the risk is known to the public so that they can make a choice on taking that risk; and,
- decreases with time as our knowledge of earthquakes and their effects improve.

In terms of priority, lives are the highest value, property a somewhat lower value, and social or economic coherence the lowest value. All, however, are important and must be considered.

The six policies that follow are intended to guide the seismic safety program of the City of San Leandro in achieving an acceptable level of risk. Under each policy is a series of suggested actions that the city might take to implement each of them.

Policy 1.

To reduce current structural hazards to an acceptable level.

City Actions:

- Conduct detailed geologic, soil, and structural analyses of critical public facilities. The most critical facilities, such as the City Hall, Public Safety Building Complex and key emergency buildings, should be reviewed first. The program should aim to inspect and mitigate several buildings each year. Appropriate mitigation can include structural modifications, changes in use, or even demolition.

- Encourage similar analyses to be performed for private commercial and industrial facilities. These structures should be examined at the cost of their owners.
- Encourage public utilities to examine the vulnerability to damage of their facilities and services, and to take appropriate measures to mitigate known problems.

Policy 2.

To prevent undue additional hazardous conditions from being created.

City Actions:

- Make this policy a part of all city or city-endorsed programs related to seismic safety.
- Discourage or control future development in seismically hazardous areas, such as those areas with unstable slopes or soils, underlying bay mud, or on or adjacent to the Hayward fault.
- Require soils and geologic investigations in areas where hazards cannot readily be avoided. The requirements should be consistent with the hazard and the proposed use.
- Adopt the latest edition of the Uniform Building Code.
- Maintain consistency between the Seismic Safety Element and other elements of the General Plan, including particularly the Housing, Land Use and Circulation Elements.

Policy 3.

To ensure adequate emergency response systems.

City Actions:

- Work with the County Office of Emergency Services in keeping the city's emergency response current.
- Regularly participate in periodic local and multi-jurisdictional disaster exercises.

Policy 4.

To place the City's program in the context of state and federal programs, and those of neighboring jurisdictions.

City Actions:

- Continue implementation of the Alquist-Priolo Act in those areas within that Act's designated Special Studies Zone.
- Arrange to use the services of the County Geologist or other registered geologic engineer in reviewing geologic reports that are prepared for proposed developments.
- Ensure that San Leandro's program is reasonably consistent with those of neighboring jurisdictions.
- Make maximum use of financial or other resources available from regional, state or federal government agencies.

Policy 5.

To increase public awareness of earthquakes and related hazards.

City Actions:

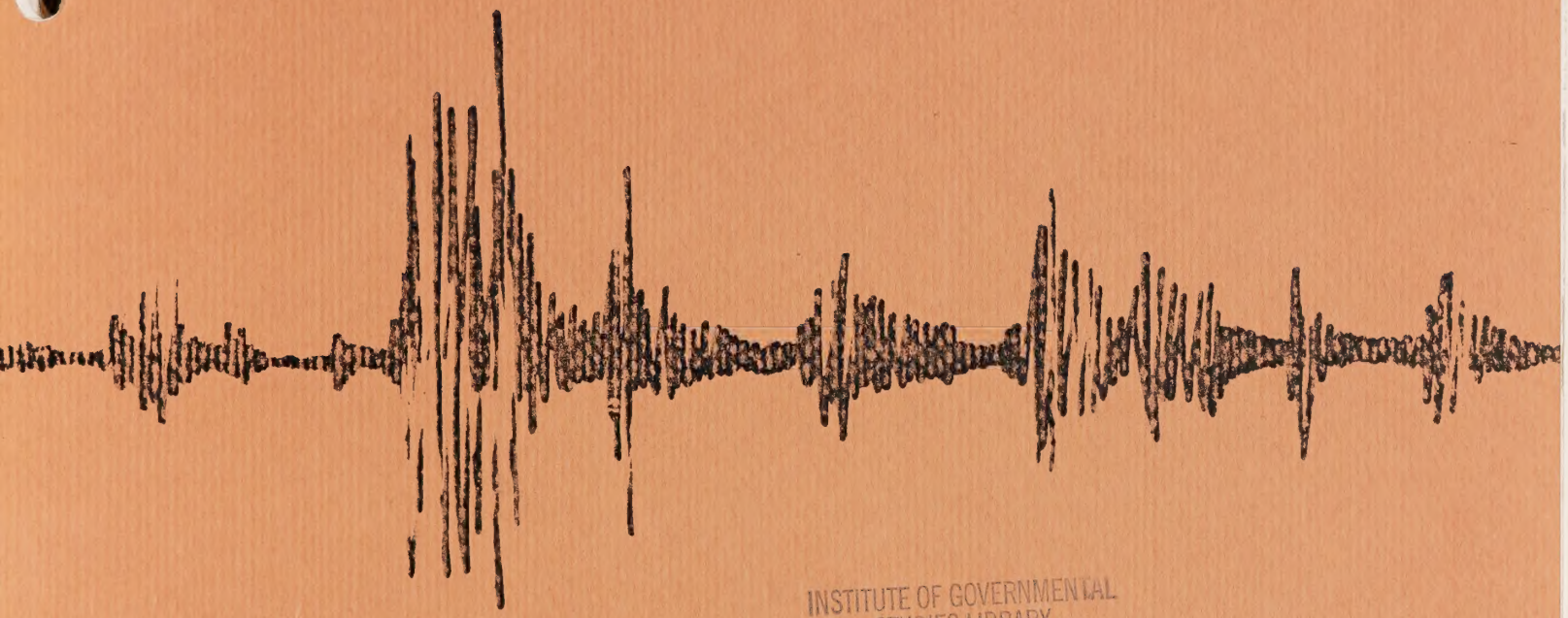
- Provide public and private organizations with information on available disaster services, or with appropriate procedures for obtaining them.
- Establish procedures for informing residents, businesses and property owners of the critical seismic hazards in the community.

Policy 6.

Adopt specific seismic safety programs annually which are consistent with the other policies of this element.

City Actions:

- Annually define a set of specific activities to be performed during the following year.
- Provide support for performing these activities in the Annual Budget and through any other appropriate funding sources.



City of San Leandro

SEISMIC SAFETY ELEMENT SUPPLEMENT

City of San Leandro

General Plan
Seismic Safety Element

Supplement

Community Development Office

July, 1977

Contents

Seismic Safety Element

I. SUMMARY AND INTRODUCTION

A. Summary of Findings

The geologic hazards existing within San Leandro are:

1. Ground rupture and displacement along the Hayward fault system in the easterly portion of the Plain and within the Foothill area as shown on Figure 1 (San Leandro Topography).
2. Ground shaking throughout all areas of the City from an earthquake on either the Hayward or the San Andreas fault system.
3. Landsliding in the Foothill area and along creek banks.
4. Liquefaction and ground failure in the westerly plain and shoreline area.
5. Seismically induced inundation along San Leandro Creek from overflow or failure of the Lake Chabot and Upper San Leandro dams or along the shoreline from a tsunamis entering S.F. Bay at the Golden Gate.

The structural hazards which were identified as a possible extension of activation of the seismic hazards summarized above are as follows:

1. Buildings
   a. Older buildings unable to meet current seismic requirements of the code. Presently the number of these structures is unknown. For example, unreinforced masonry or brick buildings lacking adequate diaphragms or large area tilt up structures designed prior to the recent San Fernando quake.
   b. The non-structural or architectural features both interior and

exterior to the building, both functional and decorative, which may collapse, fall or otherwise become dislocated by an earthquake.

2. Structures
   a. Chabot and Upper San Leandro Dams
   b. Freeway and railroad overcrossings
   c. BART structure
3. Transportation Facilities
   a. Utility mains that function as major carriers
   b. Petroleum transmission lines along Doolittle Drive and Davis Street
   c. Major roadways which must remain open to provide for rescue and evacuation routes

B. Summary of Proposed Actions

1. Establish a Seismic Safety Committee to review, recommend revisions or additions to the Seismic Safety Element to keep the element current with the state of the art.
2. Maintain and Disseminate Seismic Safety information.
3. Continue Development and Maintenance of the Disaster Preparedness Program.
4. Develop a Phoned Program to Identify, Evaluate and Mitigate Structural Hazards related to:
   a. Essential public buildings and structures
   b. Private buildings and structures where the potential for loss of life is high
   c. Architectural features on buildings facing public areas such as streets and malls

C. Introduction

The Seismic Safety Element is one of the several elements of the City's General Plan which has been prepared in response to recent State legislation requiring its development.

Section 65302(f) of the Government Code states in part as follows that the Seismic Element shall include:

> "... an identification and appraisal of seismic hazards such as susceptibility to surface ruptures from faulting, to ground shaking, to ground failures, or to effects of seismically-induced waves such as tsunamis and seiches."

> "... the seismic safety element shall also include an appraisal of mudslides, landslides, and slope stability as necessary geologic hazards that must be considered simultaneously with other hazards ..."

Thus the Seismic Safety Element is a step in directing the community's attention to limiting future earthquake losses and establishing a level of acceptable risk. Its purposes are to stimulate widespread recognition, thought, and concern regarding those seismic factors that may serve as physical constraints to land use, and to investigate and mitigate existing seismic hazards.

The legislation does not state the required content of the Element beyond the "identification and appraisal" of ground and water related seismic hazards, the intent of the law is to encourage cities and counties to take all seismic related hazards into account in their

planning programs. Basically the objectives of the legislation are to reduce the loss of life, injury, damage to property, and economic and social dislocations resulting from future earthquakes.

The State legislation has been supplemented by suggested guidelines for the preparation of the Seismic Element. These include the Suggested Interim Guidelines for the Seismic Safety Element in the General Plan by the Governor's Earthquake Council of July 14, 1972; Draft Guidelines for Local General Plans, Council of Intergovernmental Relations, June 14, 1973; and Draft Guidelines for Seismic Safety Element, prepared by the Advisory Group on Land Use Planning for a Joint Committee on Seismic Safety, California State Legislature, August 1972. The guidelines suggested by this latter group, which have been used to formulate the proposed Element for San Leandro, are as follows:

1. Preparation and adoption of a policy statement that: (a) recognizes the importance of seismic hazards and their possible effect on a community, (b) specifies acceptable risk in terms of human life and economic losses in general terms, and (c) provides a systematic program to determine the types and levels of risk and a means of controlling or minimizing them.

2. Statements of objectives in guiding land use so as to limit risk to levels acceptable to the community.

3. Identify areas of differing levels and type of seismic risk. (This would be a dynamic document, changing as new information becomes available.)

4. Statement of policy as to type of land use appropriate for each level of risk.

5. Modification of all elements of the general plan to be consistent with the seismic safety element.

6. Identification of existing structural hazards. To minimize life hazard dangers during and immediately following a major earthquake.

7. To minimize structural damage to buildings, roads, bridges, tunnels, reservoirs and utility services and in particular to public structures (schools, hospitals, offices) and services due to a major earthquake.

8. To prepare, maintain and periodically update the San Leandro Earthquake and Evacuation Plan approved May 10, 1976.

9. To provide a basis for new construction in a manner consistent with recognized seismic and geologic hazards.

10. To provide the criteria to guide the reconstruction of the City following a major earthquake.

11. Recommendations for implementation programs. Where appropriate, these might include:

    a. Recommendations for new ordinances or amendments to existing ordinances, land-use regulations, and procedures that will mandate the review, evaluation, and restriction of construction and land use that may be subject to undue risk in areas of seismic hazard; may include abatement of hazardous buildings.

    b. Incorporation of provisions for periodic revision of the Seismic Safety Element as new information becomes available, state-of-the-art knowledge advances, or acceptable levels of risk change.

D. Background

The findings set forth in this section are based on existing soil and geologic studies which have been made by various public agencies and private developers within San Leandro and the greater Bay Area. The San Leandro seismic report has drawn heavily from reports published by the United State Geological Survey and the California Division of Mines and Geology.

The findings, because they are broad in nature and do not represent the conditions at any specific site, are intended to provide guidance for general land use and building regulation decisions. The recommendations

drawn from these findings are on the side of safety; i.e. conservative. Seismic and geologic studies at specific sites may justify relaxing the recommended requirements for a specific site and conversely such studies will undoubtedly lead to more restrictive regulations in some cases. However, the findings were drawn from currently available evidence as previously noted and therefore the recommendations based on these findings are valid based on present available data. However, the recommendations must be re-evaluated as new studies become available and the state of the geologic and seismic art improves.

II. GEOLOGIC HAZARDS INVESTIGATION

A. Topography

The San Leandro area is characterized by a large plain which dips westerly from a series of north-south trending ridges on the eastern boundary. The western edge of the plain intercepts San Francisco Bay forming a shoreline approximately 5 miles in length. The plain is traversed east and west by San Leandro Creek on the north, and major flood control facilities draining the upland and foothills lying to the east.

There are several major transportation facilities that cut across the City; two freeways - Highways 580 and 17; the aerial structure of the Bay Area Rapid Transit System (BART); two railroad mainlines; the Western Pacific and the Southern Pacific. In the plain and shoreline area Southern Pacific has major track facilities and yards and paralleling Doolittle Drive and Davis there are petroleum pipelines. A transportation corridor has been established to provide yet another major roadway through the

CITY OF
SAN LEANDRO
ALAMEDA COUNTY
CALIFORNIA

SAN LEANDRO TOPOGRAPHY

FIGURE 1

western portion of the City. Further west along Neptune Drive, the pressure sewer main belonging to East Bay Dischargers Authority will transport the treated sewage effluent from San Leandro and as far south as Union City to a deep water discharge point in the central bay west of Oakland International Airport.

B. Geology

San Leandro can be viewed geologically in three sections - (1) Foothill, (2) Plain, and (3) Shoreline

Foothill

The foothill consists mainly of the same material as the bedrock in San Leandro. The bedrock is derived from the Franciscan formation of the late Jurassic to the late Cretaceous period. The Franciscan formation is a heterogenous unit of marine and volcanic sediments predominantly sandstone, siltstone and various volcanic rocks.

The slope in the area ranges from 5-50%, increasing the potential for an earthquake-induced landslide.

Plain and Shoreline

The most of San Leandro is underlain by alluvium laid down by streams emptying into the San Francisco Bay depression from the surrounding hills. The stream deposits consist of sand and gravel deposits separated and encased within extensive layers of silt and clay. Ancestral San Francisco Bay lies beneath most of the flat land areas. This is evidenced by the series of clay layers, similar to the present Bay Mud, deposited at various depths.

Bedrock lies beneath the Plain & Shoreline at depths ranging from 600 to over 1500 feet. Shoreline areas are either filled land, marshlands, or mud flats. Such land is less compacted and wetter than alluvium. Younger Bay Mud overlies most of the shoreline areas and ranges in thickness from a few feet to as much as 40 feet.

The uppermost 100 feet of Bay Mud and alluvium are of greatest interest because the behavior of the land surface is principally dependent on the nature of the sediments to that depth.

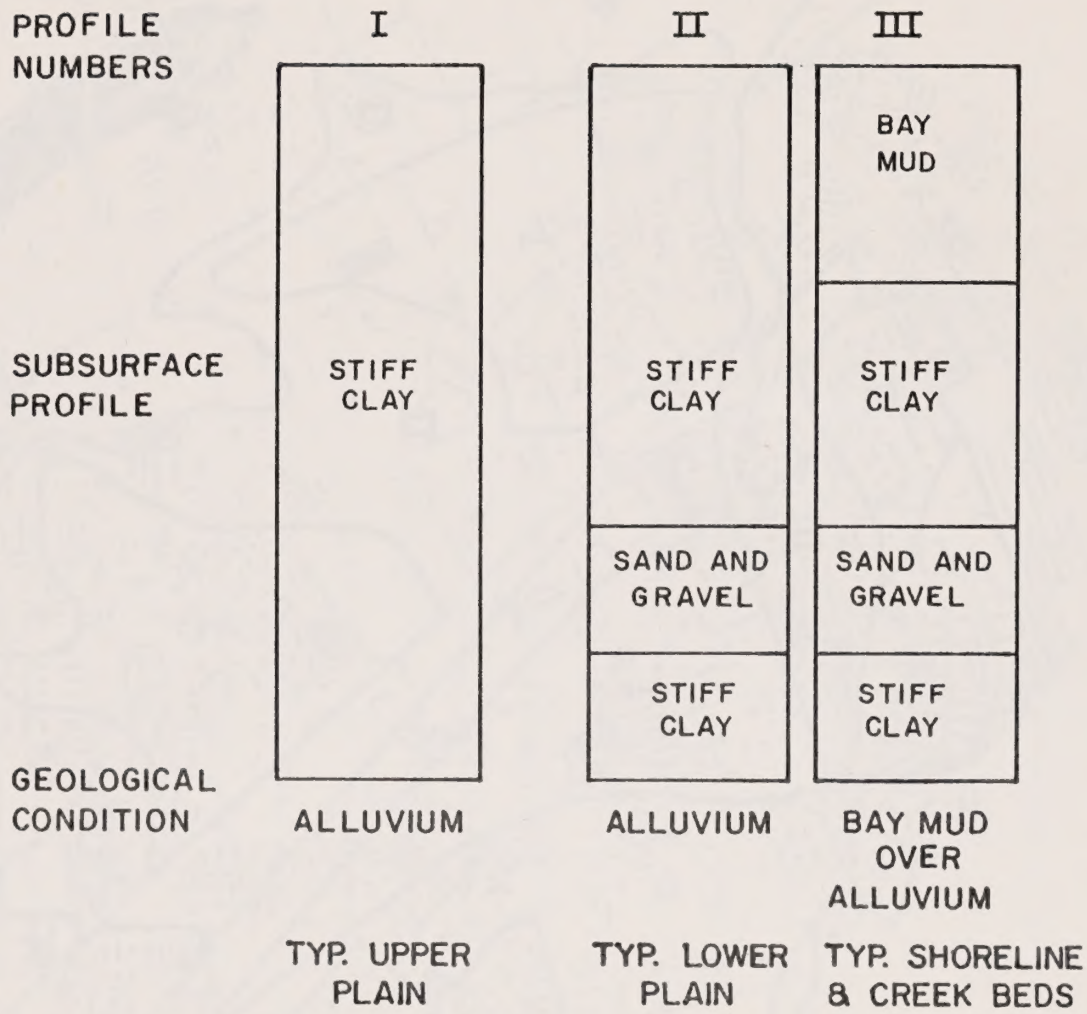
The plain and shoreline areas are characterized by certain other geologic features which determine the type and magnitude of the response of the soil to seismic activity. The soils response is expressed as the various seismic phenomena that will be induced in the area by an earthquake. The geologic features which exist in the plain and shoreline areas and will have a significant impact in the event of an earthquake are: (1) high water table; (2) presence of soft bay mud; (3) fine granular material in a loose condition, near the surface; (4) a ground elevation near or below sea level. Figure (4) shows, in general, the subsurface profiles that occur in the upper 100 feet of the Plain and Shoreline areas in San Leandro. The general areas where these profiles apply are outlined in figure (5).

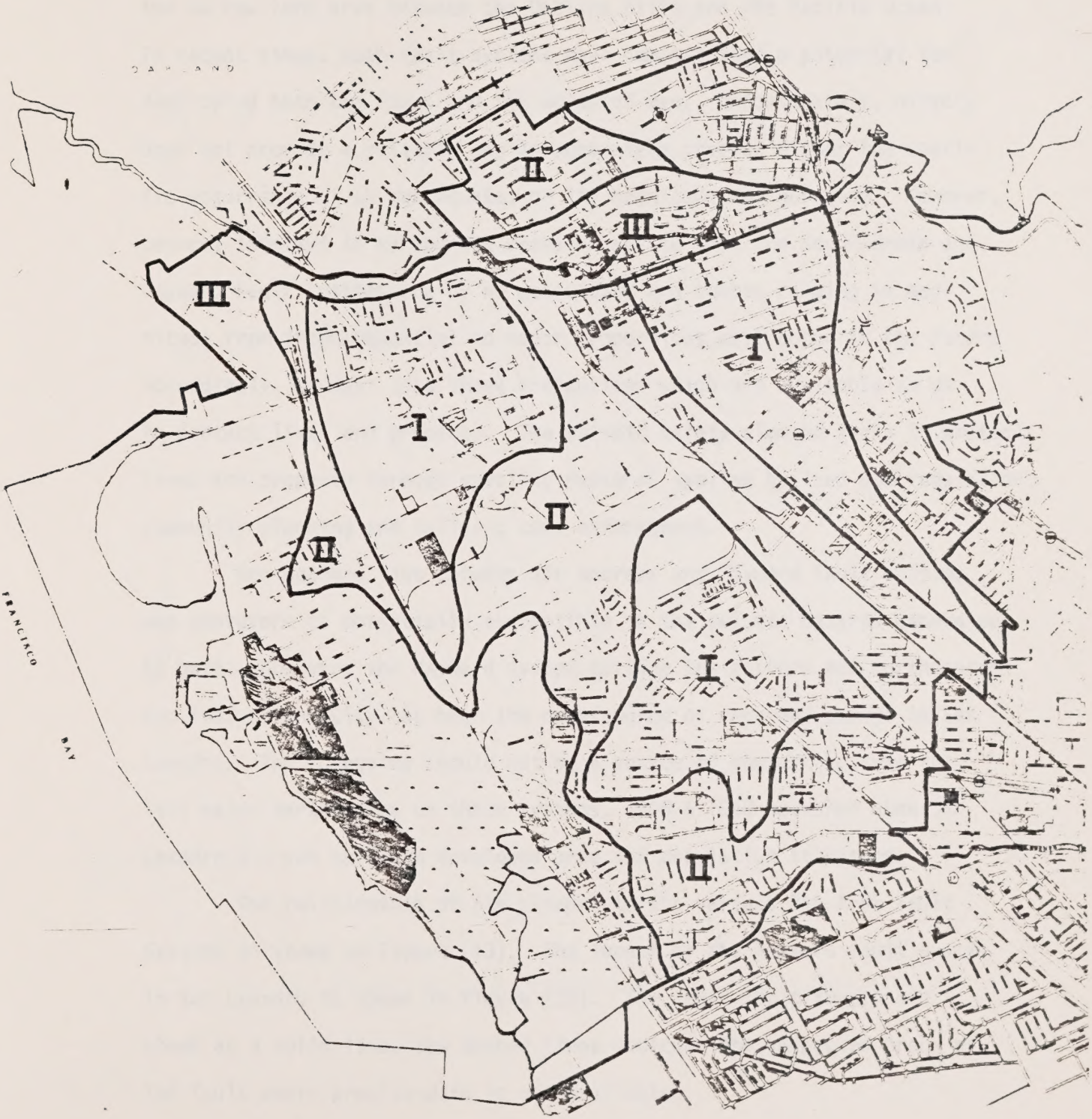
C. Active Earthquake Faults

The San Francisco Bay Area lies within one of the most seismically active and potentially destructive areas of California and the United States. Two major fault zones, the San Andreas and the Hayward

FIGURE 2

TYPICAL SUBSURFACE PROFILES





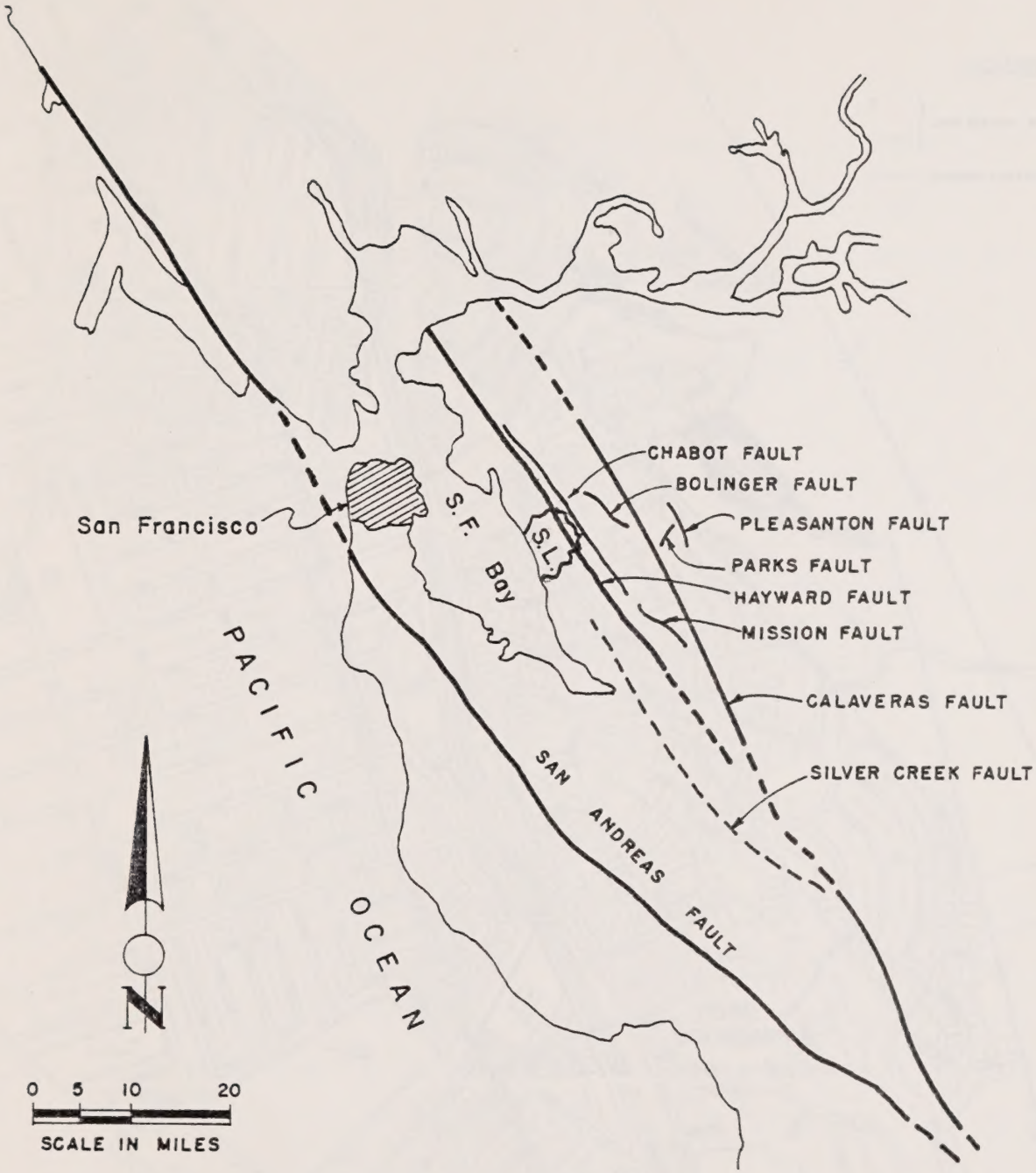
SOIL PROFILE

FIGURE 3

pass through this heavily populated metropolitan center situated on the narrow land area between the Oakland hills and the Pacific Ocean. In recent times, both fault systems have demonstrated a potential for destroying both the lives and the works of man. Unfortunately, history does not provide a reliable way to accurately predict either the specific occurrence of an earthquake, or its magnitude and duration. However, sources involved in earthquake research advise that the San Andreas and Hayward Fault systems are by no means dead and quakes ranging in magnitude from inconsequential to major proportions will occur in the future. Accordingly, we must take those precautions which are available to us to protect lives and property. The seismic safety element seeks to protect lives and property through specific measures applied by land use regulation, community planning and building code enforcement.

San Leandro lies between San Andreas and Hayward fault systems and therefore is potentially susceptible to the seismic hazards generated by both. However, the Hayward system cutting the eastern and northeastern sections of the City has been the only source of recorded damage in San Leandro. The foregoing should not be a source of comfort because the last major earthquakes on these systems, 1906 & 1868 occurred when San Leandro did not have the developed area and population it has now.

The relationship of San Leandro to the various Bay Area Fault Systems is shown on Figure (13). The impact of the Hayward fault system in San Leandro is shown in Figure (25). The known fault traces are shown as a solid line, the dashed lines indicate the suspected trace of the fault where precise data is not available.



SELECTED FAULTS IN THE SAN FRANCISCO BAY AREA

LEGEND:

- - - - SUSPECTED FAULT TRACE

——— KNOWN FAULT TRACE

FIGURE 4

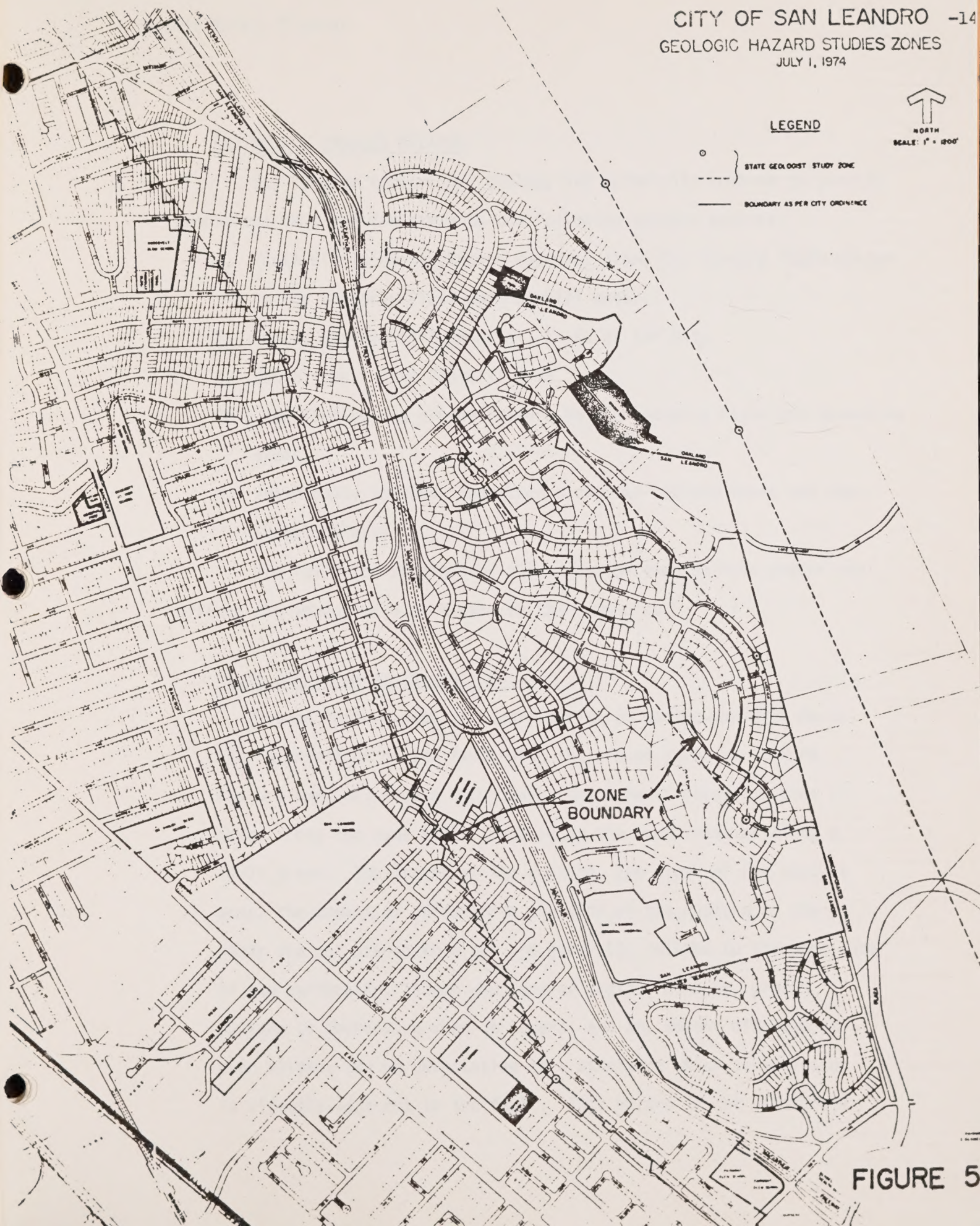

CITY OF SAN LEANDRO -14
GEOLOGIC HAZARD STUDIES ZONES
JULY 1, 1974
LEGEND
STATE GEOLOGIST STUDY ZONE
BOUNDARY AS PER CITY ORDINANCE
NORTH
SCALE: 1" = 1200'
ZONE BOUNDARY

FIGURE 5

D. EARTHQUAKE INDUCED HAZARDS

San Leandro topography, geology and seismicity combine to provide conditions that are favorable to the following seismic hazards:

1. Fault displacement (Ground rupture) along the Hayward fault system in the easterly Plain and Foothill areas.
2. Ground Shaking throughout all areas of the City.
3. Landslides in the Foothill area.
4. Liquefaction and ground failure in the westerly Plain and Shoreline areas.
5. Seismically induced inundation along San Leandro Creek and the Shoreline area.

The following sections briefly describe each seismic hazard and discuss the impact of each hazard on the community.

Fault Displacement (Ground Rupture)

Ground rupture when it occurs during an earthquake will be at the intersection of the fault with the ground surface. Ground rupture does not always occur each time a fault moves nor does it occur along the same fault trace or in the same location along a fault trace. The length of the rupture, the width of the rupture zone, the amount of offset from one side of the rupture to the other are not predictable but are generally related to the magnitude of the earthquake, length and type of fault. However, ground rupture is impressive when it occurs, and any amount of movement, even slight, can be devastating to a structure which straddles or is directly adjacent to the fault. This hazard is not widespread

in San Leandro and will impact only those structures constructed within the fault zone. Figure 25 shows the fault locations in San Leandro and the properties impacted by active fault traces. An enlarged copy of the "Geologic Hazard Studies Zone Map" showing traces of the Hayward fault in San Leandro is available for inspection in the Public Works Department.

There is no practical structural solution to combat the hazard of ground rupture, as the buildings cannot withstand the direct forces associated with this phenomenon. The best solution is to avoid building across active fault traces. The land use planning solution in this case would be to create a zone limited to uses which would minimize the risk to life and property or relegate the zone to open space, recreation or some other non-buildable, non-habitable land use.

The Alquist-Priolo Geologic Hazard Zones Act of 1972 established study zones for those faults classified by the California Division of Mines and Geology as active or potentially active. (Figure 25) The Act prohibits development in a designated study zone until fault trace location studies have shown the site to be free of an earthquake fault. In addition, it prohibits the construction of a building designated for human occupancy within 50 feet of an active fault unless it can be proven that the building is not underlain by an active fault trace (a fault that has been active during Halocene time, the last 11,000 years).

Ground Shaking

Ground shaking is the most commonly experienced, the least understood, and the most damaging earthquake phenomenon. The State Division of Mines has projected that ground shaking will be responsible for 21 billion dollars of damage in California from 1970 to 2000 (if present loss-reduction practices are not changed). The relative magnitude of this hazard is illustrated by the Division's estimate of 9.9 million dollars in damages for landsliding and 76 million dollars in damages for ground rupture during the same period.

Ground shaking is an extremely complex occurence which has eluded attempts to analyze and thereby make predictions regarding the severity and type of shaking that will result in a given area. In turn, the effect of ground shaking on structures depends on several complex factors such as, the earthquake magnitude, soil type and structure, ground water elevation, the fundamental period of the structure compared to the predominant period of the ground vibration, the shape design of the structure, and the construction materials involved.

For example, in considering the effect of ground shaking on buildings, the characteristics of the building are equal in importance in determining the outcome to the characteristics of ground shaking. A single story, 10-story, and 40-story building will have fundamental periods approximating 0.1, 1.0 and 4.0 seconds respectively. If the earthquake-induced ground shaking has the

same period as a building's fundamental period, large amplitude motions and high internal stresses can develop. If the ground shaking period is different from the building's fundamental period, the motion will be low with low internal stresses. Figure 24 graphically illustrates the relationship of fundamental period of the building to the predominant period of the ground vibration.

It is within the present state of the art in structural analysis for the fundamental period of a particular structure to be calculated with accuracy sufficient for the above purposes. However, the state of the art in calculating ground response throughout the City is not presently feasible. Therefore, for this study, an approximation was developed utilizing the concept that ground response is related to the thickness and nature of the alluvium lying above the bedrock. Using the soil and geological data described earlier, the City was divided into three zones with similar limits to those previously presented as Foothill, Plain and Shoreline. These zones are shown on Figure 6 and described as follows:

Zone GS-1

This zone consists of areas with little or no soil cover. This zone will suffer the least from shaking since lack of soil cover does not allow amplification of shaking. The period of ground motions is associated with the predominant period of the rock motions (0.2-0.3 seconds). Short period buildings are most vulnerable in this area.

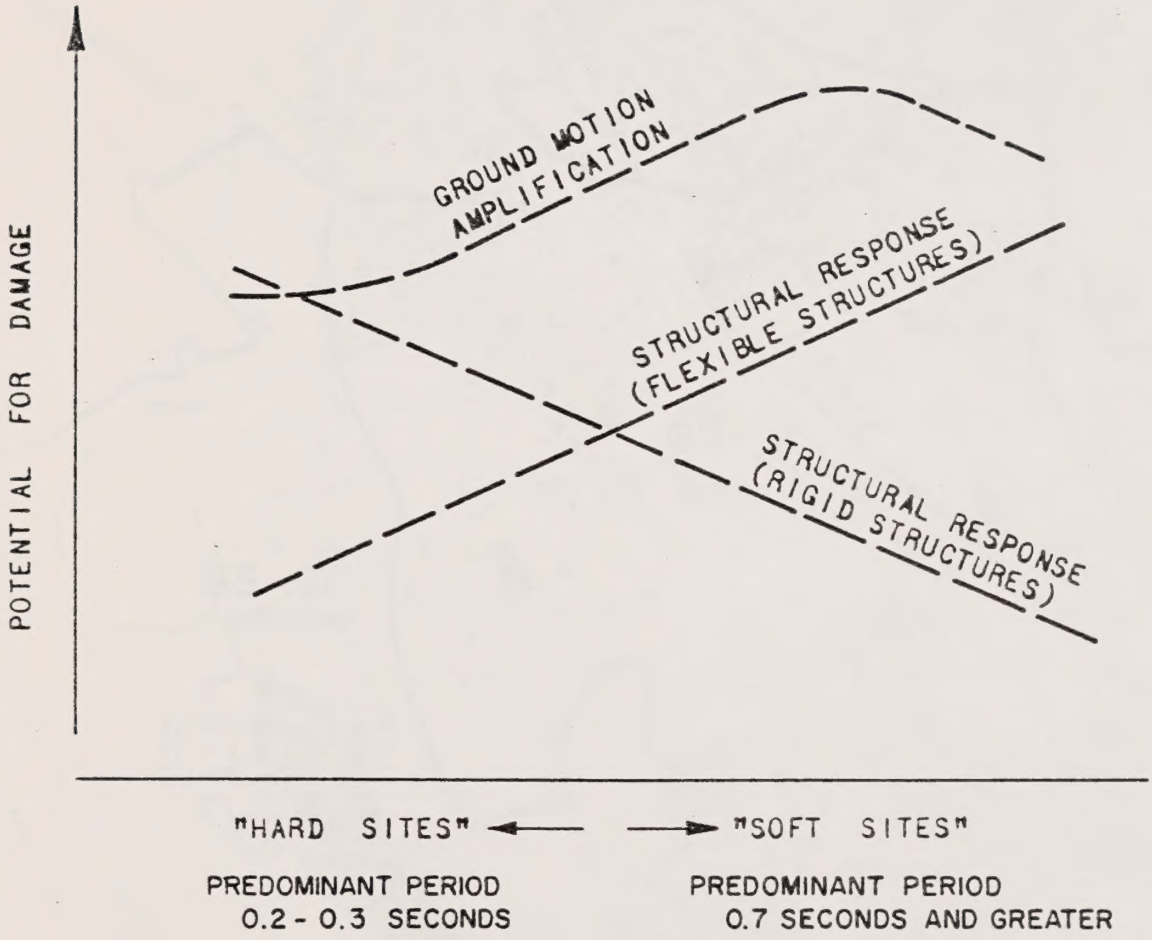
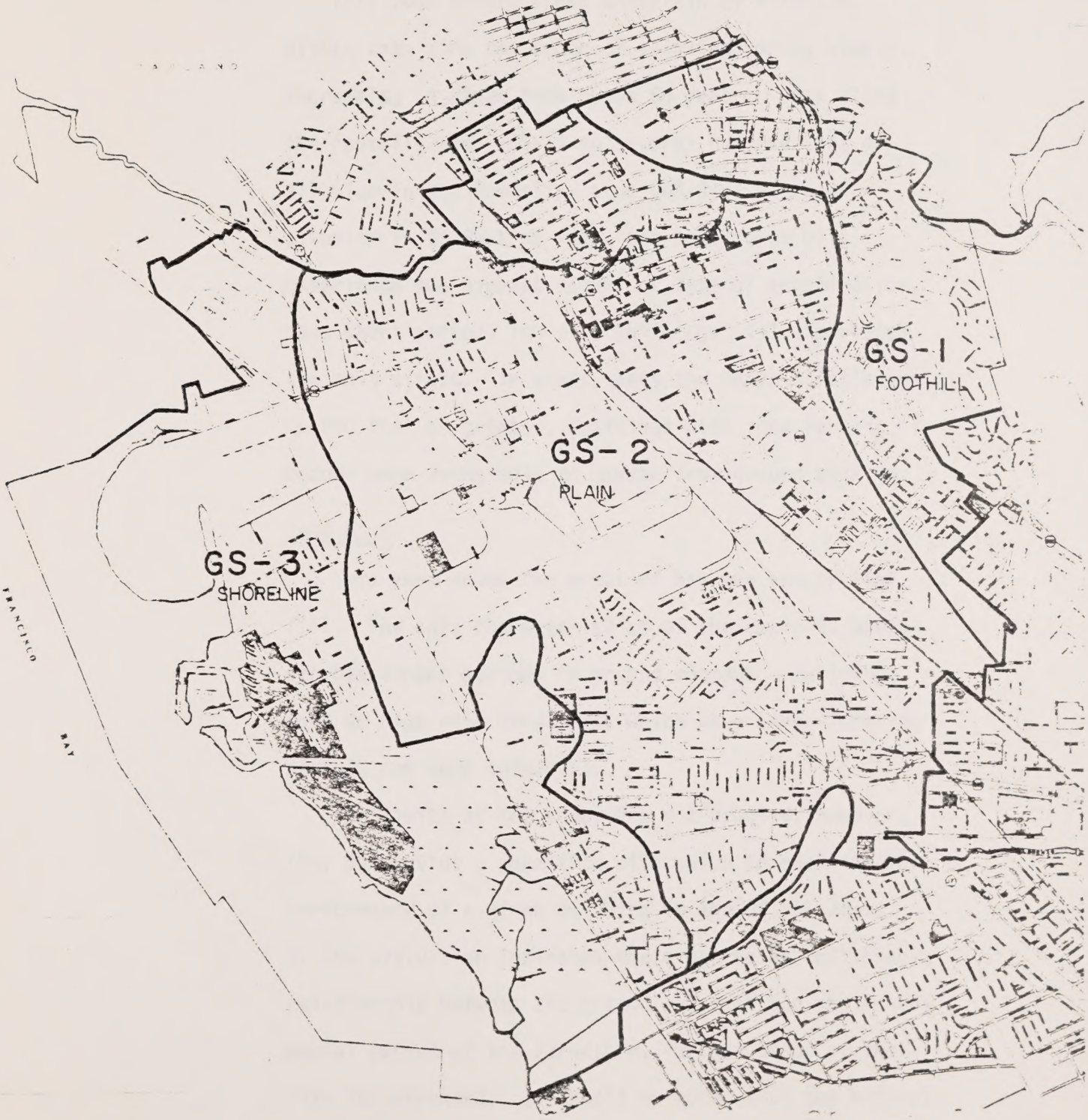


FIGURE 6

DAMAGE POTENTIAL FROM GROUND SHAKING ON "HARD" VS "SOFT" SITES



GROUND SHAKING INFLUENCE

FIGURE 7

Zone GS-2

This zone covers areas underlain by alluvium. Within this zone the depth of alluvium varies widely, increasing in depth from about 50 feet or less along the Foothill area (GS-1) to several hundred feet of alluvium in the Shoreline area (GS-3). Where the alluvium is 50 feet or less, the structures will experience the highest values of lateral acceleration, thus short period, low rise buildings will experience the most stress. In areas where the depth of alluvium is 200 feet or greater, buildings with long periods become more vulnerable to damage from ground shaking.

Zone GS-3

This zone shows the areas of bay mud and/or land fill. The soft characteristics of the deposits would promote longer periods of ground motions. Buildings such as high rise structures which have long vibration periods are very vulnerable.

The limits of the zones are not precise, however, they do provide a yardstick with which to evaluate the performance of a given building in any of the zones. If the evaluation indicates there may be an unfavorable relationship between the ground response and the fundamental period of the structure, further study of the site is warranted. It should be noted that the natural conditions in any one zone do not necessarily present

a greater hazard than in any other zone. However, the potential ground response to a seismic event in one zone may be a much greater hazard to certain types of buildings than in another zone. For example, high-rise buildings are exposed to greater hazards in deep alluvial areas as compared to areas with short depths of alluvium over the bedrock. However, seldom can a structure, without regard to its height, be declared inappropriate if it has been carefully designed specifically for the conditions at a given site. The function of the broad criteria for the ground shaking zones is to call attention to those combinations of fundamental period and ground response, which call for a detailed study prior to development.

E. Ground Failure

1. Seismically Induced Landslide

The Foothill area of San Leandro has the potential for landslides due to the steep natural slopes and the existence of man-made embankments within the Hayward fault zone. Studies of U.S. Geological Survey consider the Foothill area to be prone to landslides, however, there has been practically no landsliding in the Foothill area. This does not mean that landslides cannot be caused by an earthquake on the Hayward system since the effect, if any, of the hillside development on the stability of the slopes has not been put to the ultimate test. However, to date, the area has remained stable and we have no evidence that the construction of homesites in the Foothill area has reduced stability.

2. Liquefaction and Settlement

Liquefaction is a soil condition in which saturated, low density (loosely compacted) silts, sands and gravels are subjected to violent vibration from an earthquake. There are several changes which occur as a result. First, the granular soil layer tends to compact and decrease in volume causing settlement of the ground surface. If this soil layer is surrounded by impervious soil layers, such as dense clay, then the water filling the voids in the material either cannot escape, or does so slowly. In this case, the soil layer loses its ability to support the load imposed upon it, slowly and the resulting settlement period is extended and may not show on the surface for a considerable time or possibly not at all. The severity of the ground effect which results depends on several factors such as the thickness of the affected soil layer, the degree of confinement of the layer, and the nature of the soil layers above and below the affected layer, and the severity of the earthquake-induced ground shaking. Liquefaction is a common type of ground failure which occurs during an earthquake. In level terrain liquefaction can cause damage to structures through ground settlement, tilting (due to surface distortion), or floating (the soil becomes like quicksand). On sloping plains or hilly terrain, liquefaction can cause all or part of the slope or hillside to flow to a lower elevation causing severe damage to any structure occupying the slope.

Liquefaction is often accompanied by other forms of ground failure, namely lateral spreading, earth lurching and differential settlement. Lateral spreading occurs when saturated granular soil layers beneath a gently sloping ground surface liquify and move downhill toward its unsupported surface. This is a common shoreline occurence where granular soils are overlain by soft saturated clays such as bay mud.

Earth lurches occur commonly during earthquakes along steep natural slopes, stream banks or manmade embankments. The ground shaking causes the earth to move at right angles to its unsupported face causing the formation of cracks parallel to the unsupported face.

Differential settlement is simply the uneven compaction of a loosely consolidated material through liquefaction induced by ground shaking. Such seismically induced ground failure can severely damage structures due to the wrenching action which results from the uneven settlement across the structure's foundation.

In San Leandro the potential for liquefaction and related ground failure can be related to the already established divisions of Foothill, Plain and Shoreline areas.

The potential for liquefaction and related ground failure increases from a level of essentially low potential in the Foothills to a probable occurence in the Shoreline area.

The Foothill area is least susceptible to damage from liquefaction because of the minimal depth of overburden resting on the highly stable bedrock, the low water table and the low probability

that the existing soil layers susceptible to liquefaction will become saturated.

The Plain has a higher potential for liquefaction of granular layers comprising the much deeper layer of alluvium above the bedrock formation. The ground water table varies from about 50 feet below surface to less than 10 feet from east to west in the Plain. The high water table insures that the granular soil layers will be in a saturated condition and therefore the potential for liquefaction is increased. The types of failure to be expected throughout this area are the various forms of ground settlement; except along the creek banks and canals, where lurching may occur.

The Shoreline area has the highest potential for earthquake induced ground failure through liquefaction. The layers of saturated granular alluvium overlain by bay mud and a water table within a few feet of the surface provide the elements necessary for liquefaction. The free surface provided by the shoreline of the bay reduces the degree of confinement and increases the potential for ground failure through lateral spreading, in addition to ground failure from settlement and lurching, as in the case of the Plain.

The impact of liquefaction will be the greatest with large structures which are sensitive to differential settlement. If a high occupant load is added into this picture, it is apparent that the risk to life and property is materially increased. Presently

in San Leandro, the large structures which would be susceptible to damage from settlement within high occupant loads are not located in the area of a high potential for damage through liquefaction. Therefore, even though it is likely that there will be ground failure caused by liquefaction of the subsurface soil layers, the damage will be localized and not extensive in nature.

3. Seismically Induced Inundations

Seismically induced inundation in San Leandro could result from tsunamis entering San Francisco Bay, seiches generated in the Bay or in the EBMUD reservoirs, dam failure at Chabot or San Leandro Reservoirs, and dike failure along flood control canals or the bay shoreline.

1. Tsunamis are seismic sea waves caused by a marine earthquake or some side effect such as an underwater slide. The maximum height tsunami recorded to date at the Golden Gate was 7 feet high, generated by the 1964 Alaskan earthquake. There was no reported damage in San Leandro in this instance. Studies of the U.S. Geological Survey published in 1972 have estimated the area that would be affected by a 20 foot high tsunami entering the Golden Gate. It is estimated that a wave of this magnitude would occur once every 200 years. In Figure 9, the map published by the USGS has been updated to exclude the areas that have been filled since the federal study was completed.

The map shows that the possibility of damage in San Leandro occurring as the result of a tsunamis is extremely slight.

Seiches are waves generated by an earthquake within an enclosed or restricted body of water, such as a bay or reservoir. Seiches can be devastating if they become high enough to top the shoreline dikes or in the case of a reservoir, to top the dam. In the Bay Area there is insufficient historical record or current data regarding the occurence or impact of seiches during an earthquake. This does not imply that damaging seiches will not occur in the future, only that at present an accurate assessment of the hazard posed by seiches is not feasible.

The potential for eathquake induced dam failure has been investigated by East Bay Municipal Utility District. The analysis indicated a need to reconstruct upper San Leandro Dam. This project is currently in progress. Figure 10 shows the area which may be affected by a seiche topping Chabot Dam.

III. STRUCTURAL HAZARDS

A. Buildings and Structures

Design of buildings and structures to be earthquake safe is a complex discipline involving understanding of the physical properties of

TSUNAMIS POTENTIAL DAMAGE AREA

FIGURE 8

DISASTER FLOOD AREA:
CHABOT RESERVIOR

FIGURE 9

the structures; the nature of the supporting materials and their response characteristics; and the earthquake forces which are not precisely predictable. In the case of new construction, the combination of empiricism and theory can be applied at reasonable cost to achieve the safest structure the present state of the art can produce. However, existing older structures are difficult and expensive to bring to a safe condition. If it is technically and economically feasible to strengthen an existing building, it should be done. However, the costs of remodeling an older structure to bring it up to code may be very high compared to the remaining useful life of the structure. At some point, upgrading an old structure to current code requirements may not be worth it even if it is technically possible. In addition to the technical and economic factors, policies governing the preservation of sites of historical interest and the concept of acceptable risk to life and property may play a role in the decision of rehabilitation vs. demolition.

At present, the number of buildings and structures in San Leandro that would be classed as hazardous is not known. However, the older structures can be considered the greatest threat to life and property because of their age, type of construction and the fact that the codes at the time of construction were inadequate in the light of present state of knowledge. For example, unreinforced masonry or brick buildings with lime mortar, lacking adequate horizontal diaphragms and inadequate ties were a common type of construction that has performed poorly in earthquakes. However, these same buildings, using the same materials, properly engineered with cement mortar and steel reinforcement, will yield a safe and substantial structure.

In San Leandro these older structures are situated near the core of the City and currently occupied by commercial uses. Fortunately, the City has an effective Downtown Redevelopment Program which, in addition to renovating the City's core, is eliminating many of the older structures which are potentially the most hazardous.

Other types of structures such as low rise steel framed structures, and one-story, reinforced concrete or masonry buildings have generally performed well in earthquakes. However, the recent San Fernando earthquake revealed weaknesses in certain features of tilt-up construction, particularly in the large area structures.

Wood frame, residential structures have usually performed well in earthquakes.

High rise structures framed with steel or reinforced concrete designed to meet modern standards can be considered seismically safe. However, the stability of high rise structures is dependent upon the interrelationship of the predominant period of the ground response and the fundamental period of the structure. Much remains unknown about this relationship except in general terms as previously discussed. However, the importance of this relationship must not be overlooked in approving future high rise construction in San Leandro.

The non-structural elements of a building or structure can present a considerable seismic hazard if not properly designed or thought out. Elements such as partitions, stairs, elevators, windows, and architectural features such as parapets, tile roofs and decorative facias are subject to the same earthquake induced forces as the rest of the building or structure and they must be designed accordingly.

Interior appointments such as furniture, shelving, machinery, piping ductwork and lighting fixtures can suffer extensive damage if their anchorages are improperly designed and secured.

B. Transportation and Communication

Other types of structures which must enter into considerations of seismic safety are utilities and the City's local and regional ties to communication and transportation networks.

East Bay Municipal Utility District's storage, treatment and distribution facilities are exposed to one or more of the seismic hazards previously discussed. San Leandro is exposed to a two-fold hazard from these facilities - the loss of water supply and flooding should an earthquake rupture one of the dams above the City. The loss of water of course carries with it the potential for fire, as was the case with San Francisco in 1906.

Other utilities such as electric power and telephone will be damaged, however, alternate means for power and communication are available in the community and to some degree in most households to provide minimum services in an emergency. Natural gas transmission mains could represent a considerable hazard should they rupture during an earthquake. No area of the City would escape exposure to the potential of fire or explosion.

Liquid fuel transmission lines present a localized hazard along Doolittle Drive and west from Doolittle along Davis St. in the western section of San Leandro. A rupture of one or more of these lines with or without a fire could be deadly because the liquid fuel would spread at

ground level and eventually get into the storm drains and pump stations, making containment very difficult.

Communication systems that have importance in keeping the general public informed, such as telephone and commercial radio, will most likely suffer isolated failures but remain usable through most of the recovery period following a major earthquake. Commercial radio will no doubt be the most effective and reliable means of one-way public communication in any future crisis. First, the public has already been trained via civil defense drills and advertising to turn on their radios during any emergency. In addition, most households have at least one battery operated radio which will allow effective one-way communication should there be an area-wide power failure.

The highway system is the most vital link in an effective disaster relief program. However, the recent San Fernando earthquake illustrated that the structural design criteria used for highway structures has to be revised to prevent the collapse of bridges and overpasses. The State Department of Transportation is in the process of evaluating the San Fernando information and has initiated a program to review the State's highway structures for structural adequacy.

The disaster relief efforts in San Leandro could be severely hampered by failure of the bridges on the State Highways 580 and 17 or the elevated BART structure. Several major surface routes would be blocked by the collapse of the State's and BART's structures, effectively separating the City in a north-south direction and isolating the Foothill area from the City's emergency services. This problem is particularly relevant in San Leandro because the MacArthur Freeway lies totally within

the Geologic Hazard Zone. The projected branches of the Hayward fault system parallel and intertwine with the freeway through San Leandro. A major movement on the Hayward fault system in San Leandro has a high potential for damage to the freeway facilities and the local streets which cross over it.

IV. RECOMMENDATIONS AND AN ACTION PROGRAM

A. Acceptable Risk and Priorities for Seismic Safety

1. Acceptable Level of Risk

There is no condition of absolute safety; every aspect of life carries with it some element of risk. Since risk cannot be avoided, the dilemma then is to determine the action in each case which will result in an acceptable level of risk. What comprises an acceptable level of risk? Possibly only those who take the particular risk really know. One fact is certain, there is no uniform level of risk which is acceptable to all the "public". In addition, efforts in risk reduction will involve costs and social issues which manage to stir the emotions and tend to generate heat rather than to shed the light necessary for an acceptable decision. However, we do know the following about acceptable risk; namely the level of acceptable risk:

a. decreases as the use of a facility increases;

b. increases when the risk is known to the "public" and they may make the choice to become involved or not. (i.e., the warning labels on cigarettes and hazardous chemicals);

c. decreases with time as the state of the art improves (example: the more experience with earthquakes, the more we learn how to design to prevent failure; failures in new structures become less frequent, and public acceptance of any damage or loss of life due to an earthquake is reduced).

2. Priorities

We can assign priorities to risk taking along the following guidelines:

a. Preserving human lives is the highest priority

b. Preserving property is of moderate priority compared to preserving lives

c. Conformance with existing zoning or general land use plans, preservation of social values, etc., are of the lowest priority in considering issues bearing on seismic safety.

3. The issues of acceptable level of risk and assignment of priorities has been summarized in the following table - excerpted from the final report to the legislature titled "Meeting the Earthquake Challenge" by the Joint Committee on Seismic Safety.

Table 1 – A Scale of Acceptable Risks

Level of Acceptable Risk	Kinds of Structures	Extra Project Cost Probably Required to Reduce Risk to an Acceptable Level
1. Extremely low[1]	Structures whose continued functioning is critical, or whose failure might be catastrophic: nuclear reactors, large dams, power intertie systems, plants manufacturing or storing explosives or toxic materials	No set percentage (whatever is required for maximum attainable safety)
2. Slightly higher than under level 1[1]	Structures whose use is critically needed after a disaster: important utility centers; hospitals; fire, police, and emergency communication facilities; fire stations; and critical transportation elements such as bridges and overpasses; also smaller dams	5 to 25 percent of project cost[2]
3. Lowest possible risk to occupants of the structure[3]	Structures of high occupancy, or whose use after a disaster would be particularly convenient: schools, churches, theaters, large hotels, and other high-rise buildings housing large numbers of people, other places normally attracting large concentrations of people, civic buildings such as fire stations, secondary utility structures, extremely large commercial enterprises, most roads, alternative or noncritical bridges and overpasses.	5 to 15 percent of project cost[4]
4. An "ordinary" level of risk to occupants of the structure[3,5]	The vast majority of structures: most commercial and industrial buildings, small hotels and apartment buildings, and single family residences.	1 to 2 percent of project cost, in most cases (2 to 10 percent of project cost in a minority of cases)[4]

[1] Failure of a single structure may affect substantial populations.

[2] These additional percentages are based on the assumption that the base cost is the total cost of the building or other facility when ready for occupancy. In addition, it is assumed that the structure would have been designed and built in accordance with current California practice. Moreover, the estimated additional cost presumes that structures in this acceptable-risk category are to embody sufficient safety to remain functional following an earthquake.

[3] Failure of a single structure would affect primarily only the occupants.

[4] These additional percentages are based on the assumption that the base cost is the total cost of the building or facility when ready for occupancy. In addition, it is assumed that the structures would have been designed and built in accordance with current California practice. Moreover the estimated additional cost presumes that structures in this acceptable-risk category are to be sufficiently safe to give reasonable assurance of preventing injury or loss of life during and earthquake, but otherwise not necessarily to remain functional.

[5] "Ordinary risk": Resist minor earthquakes without damage; resist moderate earthquakes without structural damage, but with some non-structural damage; resist major earthquakes of the intensity or severity of the strongest experienced in California, without collapse, but with some structural as well as nonstructural damage. In most structures, it is expected that structural damage, even in a major earthquake, could be limited to repairable damage. (Structural Engineers Association of California).

B. Current Structural Hazards

1. Structural Review of Essential Facilities

Certain types of structures and facilities, which are particularly important in post-disaster response, such as hospitals, emergency power installations, emergency operating centers, public safety facilities, public utilities and essential elements of key communications systems, should be reviewed for their structural adequacy and ability to survive a major earthquake, and continue to function.

The buildings which house vital governmental functions necessary to coordinate post-disaster activity and public buildings which can serve as a refuge should be adequately reinforced to meet the most rigid earthquake standards.

2. Structural Review of Non-Essential Facilities

The City should actively pursue a policy that will achieve the structural review of existing high occupancy commercial and industrial buildings.

Buildings which incorporate architectural features such as parapets, ornamental tile or slate roofs and decorative structures which border on public open space should be evaluated and any hazard mitigated early in the program.

3. Information on Seismic Safety

Information relating to seismic safety should be made available to the public, such as hazard zone maps, emergency preparedness plans, evacuation plans, and other related seismic safety programs and measures, as they are developed.

Public participation is to be encouraged in evolving seismic safety policies and programs consistent with the community's concept of acceptable risk.

City policy should encourage an aggressive program in training and education of the citizens of San Leandro and City staff in earthquake safety and disaster preparedness.

4. Disaster Response Plan

The City should continue to develop and refine its disaster response capabilities by continuing to update its Emergency Operations Plan, maintaining an inventory of basic emergency material and equipment and conducting training exercises to keep the organization in a high state of readiness.

C. Preventing the Creation of New Hazards

1. General Policy

City planning and development programs should place a high priority on seismic safety both locally and regionally.

2. Soils and Geologic Studies

Require soils and geologic studies of sites where the nature of the use and/or the type of construction would endanger life or result in major property damage in the event of a major earthquake on either the San Andreas or the Hayward fault systems.

3. Controlled Development

Discourage development of sites where the seismic hazard cannot be mitigated through design or other measures.

4. Codes

Maintain the various City codes relating to building construction and earthquake safety current with the new developments in the state of the art through an annual program to review and revise these documents as required to promote the goal of seismic safety at an acceptable level of risk.

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City of San Leandro

SEISMIC SAFETY ELEMENT

SUPPLEMENT